Section 8: Polar Bears

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Movements and Population Dynamics of Polar Bears

Polar bears (*Ursus maritimus*) are hunted throughout most of their range. In addition to hunting, polar bears of the Beaufort Sea region are exposed to mineral and petroleum extraction and related human activities such as shipping, road-building, and seismic testing (Stirling 1990).

Little was known at the start of this project about how polar bears move about in their environment; and although it was understood that many bears travel across political borders, the boundaries of populations had not been delineated (Amstrup 1986, Amstrup et al. 1986, Amstrup and DeMaster 1988, Garner et al. 1994, Amstrup 1995, Amstrup et al. 1995, Amstrup 2000).

As human populations increase and demands for polar bears and other arctic resources escalate, managers must know the sizes and distributions of the polar bear populations. Resource managers also need reliable estimates of breeding rates, reproductive intervals, litter sizes, and survival of young and adults.

Our objectives for this research were 1) to determine the seasonal and annual movements of polar bears in the Beaufort Sea, 2) to define the boundaries of the population(s) using this region, 3) to determine the size and status of the Beaufort Sea polar bear population, and 4) to establish reproduction and survival rates (Amstrup 2000).

One-hundred-fifty-three satellite radio collars (PTTs), fitted to 106 adult female polar bears in the Beaufort Sea, were relocated 37,277 times between 1985 and 1993 (Amstrup 1995, Amstrup 2000, Amstrup et al. 2000). Polar bears were observed to move more than 4 km/hr for extended periods, but mean hourly rates of movement varied from 0.30-0.96 km/hr. Females with cubs had lower hourly rates of movement than females with yearlings and those (single females) without young.

Movement rates varied significantly among months: they generally were lowest in spring and late summer and highest in early winter (Amstrup 1995, Amstrup et al. 2000). Geographic displacements from the beginning to the end of each month were smaller for females with cubs of the year than for single females, and larger in November than in April.

In May, June, July, and August, radio-collared bears shifted locations to the north. Collared bears moved back to the south in October. Mean total distances moved each month ranged from 186-492 km. Total movements in December were larger than those measured in April, May, July, August, and September, and total monthly

movements of females with cubs were lower than single females.

Total annual movements ranged from 1,454-6,203 km. Bears that spent part of the year in dens moved less than others, but non-denning classes of bears did not differ in total annual movement (Amstrup 1995, Amstrup et al. 2000).

Females with cubs were generally the most active group, and single females the least active. Highest and lowest levels of activity were recorded in June and September, but there also was a strong activity peak in early winter. Activity levels were lowest in the early morning and higher from mid-day through late evening.

Beaufort Sea polar bears kept their movements within boundaries outside of which they seldom ventured. Annual activity areas ranged from 12,730 km^2 to 596,800 km^2. Monthly activity areas ranged from a mean of 344 km^2 for females with cubs in April to 11,926 km^2 for females with yearlings in December (Amstrup 1995, Amstrup et al. 2000).

Bears from the Beaufort Sea population occupied an area extending up to 300 km offshore, from Cape Bathurst in Canada to Pt. Hope, Alaska, and enclosing 939,153 km^2 (Amstrup et al. 1986, Garner et al. 1994, Amstrup 2000).

Animals originally captured along the Beaufort Sea coast spent approximately 25% of their time in the northeastern Chukchi Sea, but animals captured in the Chukchi Sea ventured into the Beaufort Sea only 6% of the time. With few exceptions (Durner and Amstrup 1995) bears captured in the Beaufort Sea were faithful to summer activity areas in the central portion of the Beaufort Sea (Amstrup et al. 1986, Amstrup 1995, Amstrup et al. 1995, Amstrup et al. 2000). Although any bear caught in this region could be relocated anywhere else in the region, individual bears appeared faithful to general geographic regions (Fig. 8.1). Recent analyses of patterns in seasonal fidelity of polar bears (Bethke et al. 1996) suggested that 3 separate populations or stocks could be distinguished.

These 3 relatively discrete stocks overlap to a greater or lesser extent within Alaska waters (S. C. Amstrup, U.S. Geological Survey, unpublished data). Therefore, it is no longer reasonable to refer to only 1 group of polar bears (Amstrup 1995, Amstrup 2000) occupying this region (Amstrup et al. 2001). Although these groups are not distinguishable genetically (Paetkau et al. 1999), they are distinct enough to mandate management recognition.

Two groups, the Chukchi Sea and the Southern Beaufort Sea populations, share the mainland coastal areas of Alaska in the greatest numbers (Amstrup et al. 2001). Recognition of these stocks helps to explain some of the movement patterns previously observed. These 2 groups supply most of the harvest of polar bears that
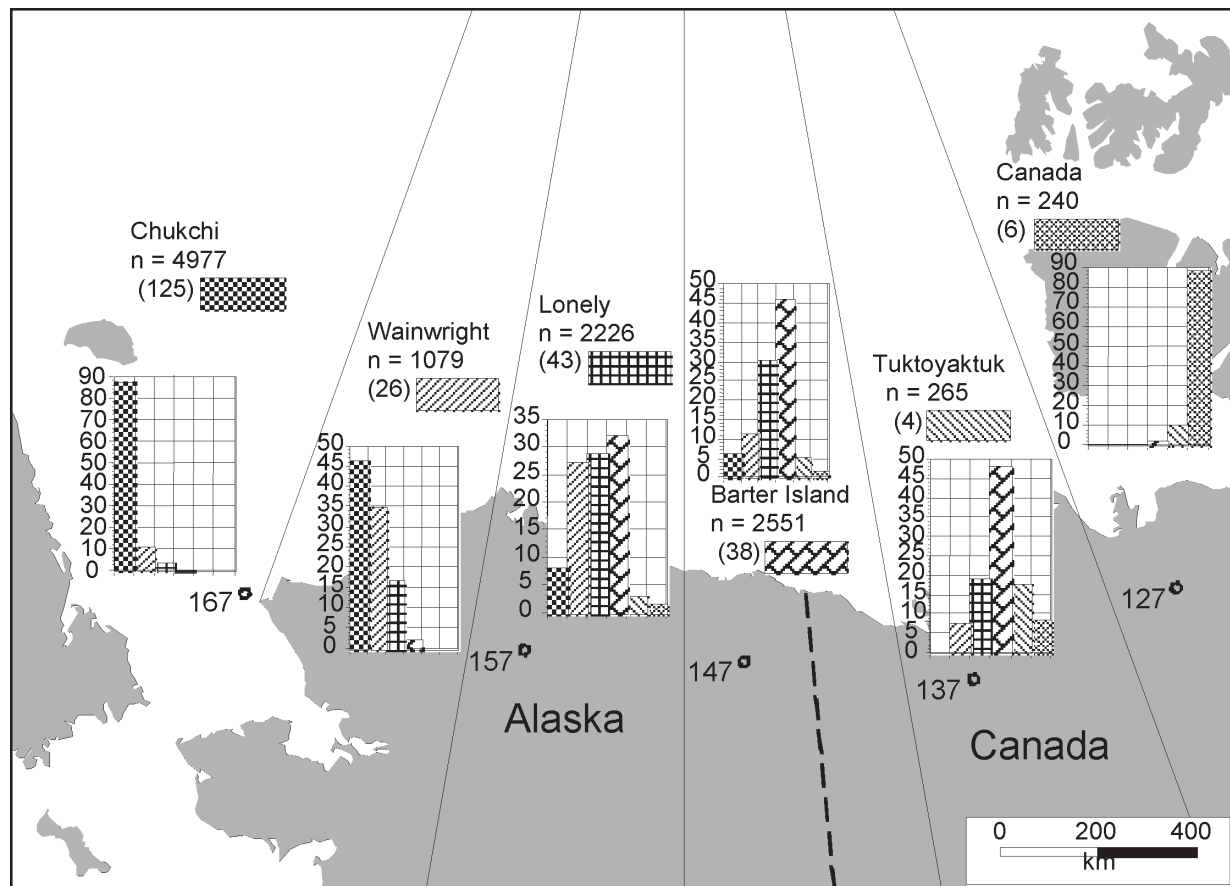
Figure 8.1. Numbers and relocation positions of satellite radio-collared polar bears (# of individuals) captured in each of 6 longitudinal zones within the Beaufort Sea. Histograms illustrate proportions of those relocations made in each zone. For example, 32% of the 2,226 relocations of bears originally captured in the Lonely zone were recorded in the Barter Island zone, Alaska; 47% of the 1,079 relocations of bears captured in the Wainwright zone, Alaska, were recorded in the Chukchi zone.

occurs in Alaska and much of the harvest along the mainland coast of northwestern Canada.

Data were analyzed for 589 captures of 534 bears between 1967-1974 (a period of hypothesized over-harvest) and for 1,087 captures of 789 bears obtained between 1981-1992 (a period when the population should have recovered from over-harvest). Population growth throughout the intervening years was also examined (Amstrup 1995, Amstrup et al. 2001).

Amstrup et al. (2001) and McDonald and Amstrup (2001) suggested that the number of polar bears in the Southern Beaufort Sea population grew at more than 3% per year between 1967 and 1998, reaching an estimated population that could be as high as 2,500 animals.

Although contact with hydrocarbons can have serious ramifications for polar bears (Amstrup et al. 1989), the polar bear's apparent rapid population growth has spanned the entire history of petroleum development in arctic Alaska (Amstrup 2000, Amstrup et al. 2001, McDonald and Amstrup 2001). This suggests that managed resource development can be compatible with healthy polar bear populations. Also encouraging is the new ability to estimate potential impacts that oil spills may have on polar bears. That ability has major ramifications for assessing risks of a variety of potential developments (Durner et al. 2001*b*).

Both long and short-term trends in condition of individual animals were observed during this study. Condition of adult females, as reflected by total mass, showed significant seasonal trends (Durner and Amstrup 1996). Despite seasonal fluctuations, longer-term trends also were suggested. Trends in recruitment and survival rates (in the 1970s compared with those from 1980 through 1992) suggested an inverse compensatory relationship between total population size and recruitment of subadults. Population size alone explained 55% of the variation in proportions of 2- and 3-year-olds in annual samples (Amstrup 1995). Large populations of the latter part of the study appeared to recruit proportionately fewer juveniles, and smaller populations of the early part of the study recruited higher proportions of juveniles.

Condition of single adult females and those with cubs, as reflected in measurements of axial girth, appeared to decline significantly as the population grew. Population

size alone explained 75% of the variation in axial girth of reproductive age females.

Although numbers of young produced per female when the population was small (<0.40) and when it was large (<0.38) were similar, litters of more than one yearling were more frequent when the population was small. Sampling inconsistencies during the 2 periods precluded comparison across years for cubs and 2-year-olds but not for yearlings. Observed reproductive intervals of 3.4 and 3.7 years in early and late periods were suggestive of change, but not significantly different (Amstrup 1995). The age structure of the small population was younger than that of the larger population of later years.

Survival of adults, as calculated from life tables, was higher and survival of young lower when the population was large. Survival rates of adult Beaufort Sea polar bears, however, were as high or higher than those measured anywhere else. Annual survival of radio-collared females ranged from 0.946-0.980 (Amstrup and Durner 1995). Survival of cubs ranged between 0.610 and 0.675, while that of yearlings was 0.751-0.903.

In this study hunting explained 85% of the documented deaths of adult female polar bears (Amstrup and Durner 1995). Natural mortalities were not commonly observed among prime age animals (Amstrup and Nielsen 1989), and we still know little about the proximate causes of natural deaths among polar bears.

In the early 1990s, the trends described above suggested a population that could be approaching carrying capacity and was either stable or growing more slowly than in the early 1980s. More recent data suggest an alternate hypothesis: Apparent density dependence was a function of more transitory ecological effects. The apparent continued growth of the population into the late 1990s and the expansion of numbers of maternal dens as well as expanded areas used for denning (*see below*) appear to contradict earlier conclusions regarding carrying capacity and density effects. This suggests that issues related to population status should be revisited (Amstrup et al. 1986, Amstrup 1995, Amstrup et al. 2001, McDonald and Amstrup 2001).

Estimated numbers of bears at the close of the study were relatively large. Effects of the increasing human intrusions into the polar bear environment have not been observed at a population level, suggesting that proactive management can assure coexistence of polar bears and human developments.

Absolute numbers of bears, however, still are small compared to many other species. Early estimates suggested the additional loss of as few as 30 bears each year might push the total take from the population to the maximum sustained yield (Amstrup et al 1986, Amstrup and DeMaster 1988). Excess take did precipitate a decline in the 1960s and 1970s. Hence, although populations may now be near historic highs, managers must be alert to possible changes in human activities, including hunting and habitat alterations that could precipitate future declines.

Reproductive Significance of Maternity Denning on Land

The distribution of polar bears is circumpolar in the Northern Hemisphere, but maternal dens known at the start of this project were concentrated in relatively few, widely scattered locations (Amstrup 1986, Amstrup et al. 1986, Amstrup and DeMaster 1988, Amstrup and Gardner 1994).

Among the best-known denning concentration areas were the Svalbard Archipelago north of Norway; Franz Josef Land, Novaya Zemlya, and Wrangel Island in Russia; and the west coast of Hudson Bay in Canada. Denning was either uncommon or unknown in gaps between known denning concentration areas. The Beaufort Sea region of Alaska and Canada lay in the largest of those gaps, and some had hypothesized that polar bears of this region actually were born in other areas.

Now we realize that the coastal plain area of the Arctic National Wildlife Refuge lies in a region of polar bear denning; and its coastal plain also may contain significant gas and oil resources. Polar bears in dens could be affected in many ways by petroleum development, but neither the distribution of dens nor the sensitivity of bears in dens was known before our research (Amstrup 1986, Amstrup and DeMaster 1988).

To ascertain the number and distribution of denning polar bears that could be impacted by oil development on the Arctic Refuge coastal plain, we established the following research objectives: 1) to determine the distribution of polar bear dens in northern Alaska, 2) to ascertain the time that polar bears enter and emerge from dens, 3) to calculate the relative success rates of dens on land and on sea ice, and 4) to determine whether oil and gas exploration and development of the Arctic Refuge coastal plain would adversely impact polar bears of the Beaufort Sea by disrupting denning activities.

Polar bears were captured and radio-collared between 1981 and 1992. Amstrup and Gardner (1994) determined that denning in the Beaufort Sea region was sufficient to account for the estimated population. They also noted that the proportion of dens on land was higher in the late 1980s and early 1990s than it was earlier in the study (Fig. 8.2). That trend continues, and other distributional changes also may have occurred in the late 1990s and early 2000s. Of a total of 182 dens located by telemetry between spring of 1982 and spring of 2001, 150 were within the study area from 167° to 137° W longitude (Point Hope to Mackenzie River). Polar bear dens in this
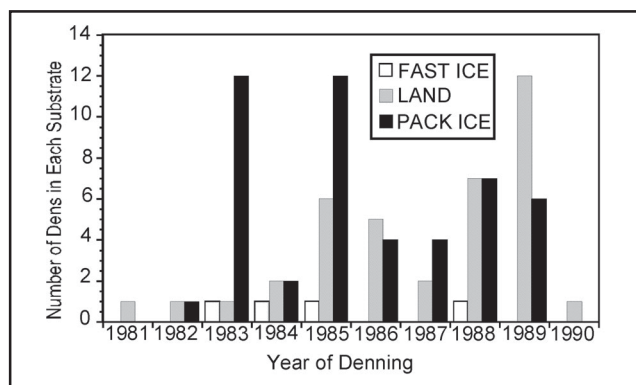
Figure 8.2. Number of polar bear dens located by radio-telemetry in each of 3 substrates, 1981-1990.

region continued to occur on land, pack ice, and land-fast ice.

Seventy-three of the 150 maternal dens discovered by telemetry between 167° W and 137° W were on land or land-fast ice where they were potentially vulnerable to a variety of human disturbances.

The remaining 77 identified maternal dens were on drifting pack ice where they were relatively invulnerable to most human activities. The proportion of pack-ice dens dropped dramatically in the latter half of the study. A decrease in study effort in offshore regions in the late 1990s may explain a portion of the decline in numbers of dens found on pack ice. Bears denning on pack ice drifted as far as 997 km while in dens and were potentially vulnerable to a variety of natural forces that could compromise their security while occupying dens (Amstrup and Garner 1994).

There was no difference in cub production by bears denning on land and pack ice. Mean entry and exit dates were 11 November and 5 April for land dens and 22 November and 26 March for pack-ice dens (Amstrup and Gardner 1994).

Female polar bears captured in the Beaufort Sea appeared to be isolated from those caught east of Cape Bathurst in Canada. Bears followed to >1 den did not reuse sites, and consecutive dens were from 20 km to 1,304 km apart (Fig. 8.3). However, radio-collared bears were usually faithful to substrate (pack ice, land, land-fast ice) and the general geographic area of previous dens (Amstrup and Gardner 1994).

Of the 73 dens found by radio telemetry on the mainland coast of Alaska and Canada (land plus fast-ice dens), 32 (44%) were within the bounds of the Arctic Refuge and 24 (33%) were within the 1002 Area.

The proportion of dens located on the Arctic Refuge dropped from 47% to 41% when the periods before and after 1992 were compared, while the proportion of dens located within the bounds of the 1002 area dropped from 36% to 30%. The decrease in proportion of land dens on the Arctic Refuge was accompanied by an increase in the proportion of dens found on land areas west of the Arctic Refuge. Although this distribution shift is not statistically significant (Chi-square test $P = 0.88$), it is readily apparent on the map (Fig. 8.4).

The shift may be explained simply by sample size limitations. The continuing growth in polar bear numbers, the continuing trend in proportion of dens on land, and perhaps changing freeze-up conditions in the last decade all may be influencing the distribution of denning efforts. The apparent increase in numbers of bears denning on land and the increased land area used for denning corroborates estimates, reported earlier, that suggested a continued increase in total numbers of polar bears
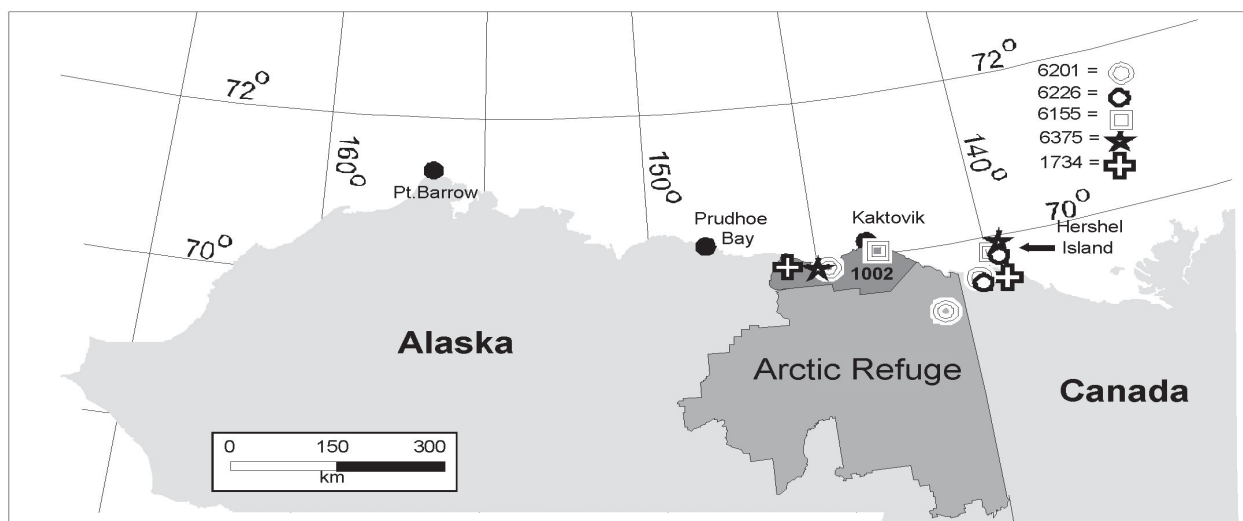

Figure 8.3. Maternal den locations for 5 polar bears followed to dens for more than one year. All dens were located by radio telemetry. Bears repeatedly denned in the same general geographic area, but not the same place. Likewise, polar bears repeatedly denned in the same substrate. (*from* Amstrup and Gardner 1994)
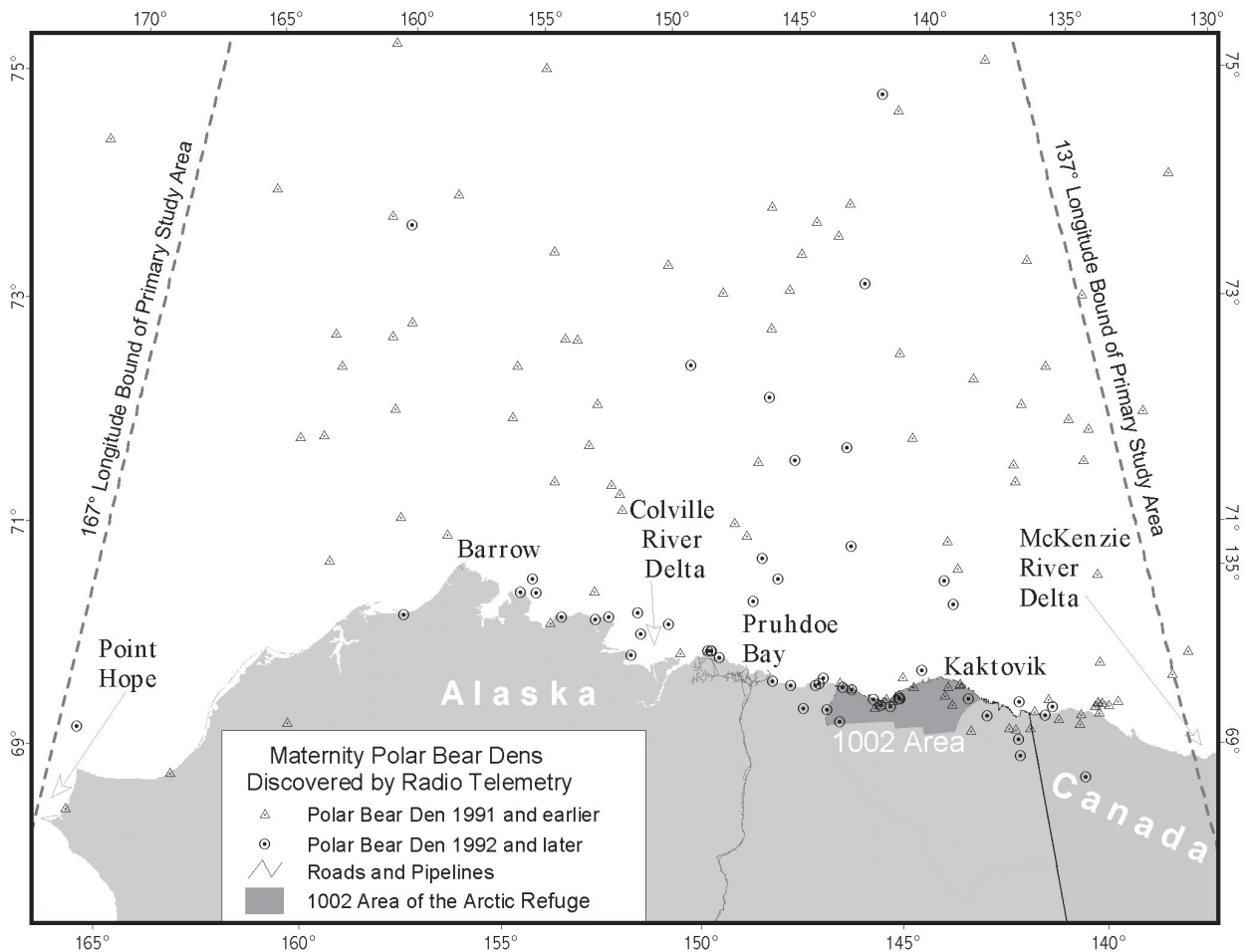
Figure 8.4. Distribution of maternal dens of radio-collared polar bears along the northern coast of Alaska and Canada, 1981-2001. (*updated from* Amstrup and Gardner 1994)

throughout the study period. The distribution of maternal denning continues to be a fertile area for future research.

Despite a possible decline in proportional use of the Arctic Refuge for denning, there still appears to be a higher concentration of dens on the Arctic Refuge than on adjacent lands. Development of hydrocarbon resources therefore could increase the potential for disturbance of denning polar bears by human activities.

Because the chronology of denning is now known, however, human activities could be temporally managed to minimize exposure of denning bears (Amstrup 1993, Amstrup and Gardner 1994). Spatial management of industrial activities could further minimize exposure of dens to disturbances because denning occurs in low density (including the Arctic Refuge) within relatively uncommon habitats that can be mapped (Amstrup 1993, Durner et al. 2001*a*).

Available data indicate polar bears are relatively resilient to disturbances coming from outside their dens (Amstrup 1993, Amstrup and Gardner 1994). Data showed that dens exposed to even high levels of activity did not suffer a detectable reduction in productivity

(Amstrup 1993). Perturbations resulting from capture, marking, and radio tracking maternal bears did not affect litter sizes or stature of cubs produced; and 10 of 12 denned polar bears exposed to exceptional levels of activity were not measurably affected (Amstrup 1993).

Hence, polar bears in dens may be less vulnerable to human disturbances than previously thought. This finding corroborates the observations of Blix and Lentfer (1992) who reported that polar bears in dens are well insulated from disruptions outside of their dens.

Aggressive and proactive management, therefore, can minimize or eliminate most of the potential adverse effects of human developments on denning polar bears. It will be important to conduct research and monitoring of polar bear denning and ecology concurrent with any approved developments to assure that management efforts do have the desired mitigation effects.

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